Remarks.

Dec. 18, 1873. For a second series of 15 on this day no first effect was found.

Jan. 15, 1874. There was a sudden change of the current during the experiments, to which the unusually small effect is most likely due.

Jan. 16. There was a sudden change of the current during the experiments, to which the unusually large effect is most likely due.

Jan. 17. There was an irregularity at the beginning of the experiment.

Jan. 20. Action somewhat irregular.

Jan. 22. There seemed to be a first effect of the current on itself in the opposite direction, 0—14—9.

Jan. 26. There seemed to be again a first effect in opposite direction, 0—47—57.

Jan. 27. Ditto Ditto 0—17—17.

Jan. 28. The action was very irregular.

Jan. 29. It is suspected that during the experiments from Jan. 29 to Feb. 12 the contact at the key was not very good.

Feb. 3. The action was very irregular.

Feb. 4. There seemed to be two first effects of the current upon itself in the direction of increased resistance.

Feb. 5. The action was very irregular.

Feb. 6. There seemed to be a first effect of decreased resistance of current upon itself.

Feb. 11. The wires had been broken since Feb. 6th.

Feb. 12. One of the wires had got between the pole and the core of the magnet.

Feb. 24. After the first on (2) the magnet was always put on (1).

II. "Note on some Winter Thermometric Observations in the Alps." By E. Frankland, F.R.S.

During the past winter, I spent a fortnight at the village of Davos, Canton Graubünden, Switzerland, and had thus an opportunity of experiencing some of the remarkable peculiarities of the climate of the elevated valley (the Prättigau) in which Davos is situated. The village has of late acquired considerable repute as a climatic sanitarium for persons suffering from diseases of the chest. So rapidly has its reputation grown, that while in the winter of 1865–66 only eight patients resided there, during the past season upwards of three hundred have wintered in the valley.

The summer climate of Davos is very similar to that of Pontresina and St. Moritz, in the neighbouring high valley of the Engadin—cool and rather windy; but so soon as the Prättigau and surrounding mountains become thickly and, for the winter, permanently covered with snow, which usually happens in November, a new set of conditions come into play and the winter climate becomes exceedingly remarkable. The sky is, as a rule, cloudless or nearly so; and, as the solar rays, though very powerful, are incompetent to melt the snow, they have little effect upon the temperature, either of the valley or its enclosing mountains; consequently there are no currents of heated air; and, as the valley is well sheltered from more general atmospheric movements, an almost uniform calm prevails until the snow melts in spring.

According to Dufour's trigonometrical measurements, Davos is 1556 metres, or 5105 feet, above the sea; the measurements of the Swiss Meteorological Society make the height 1650 metres, or 5413 feet; and my own estimation with an aneroid gave it as 4000 feet above Zürich, or 5352 feet above the sea. The village of Davos is therefore about 500 feet lower than the summit of the Rigi.

I arrived on the evening of the 20th of December, and found the snow lying from two to three feet deep on the flat sole of the valley. On the following morning the thermometric observations were commenced with instruments supplied to me by Mr. L. Casella, all of which had been certified at the Kew Observatory. For the corresponding readings at Greenwich I am indebted to Mr. Glaisher.

December 21*st*, 1873.—From behind the sharp peak of the Schwarzhorn the sun rose at the Seehof Hotel, Davos-Dörfli, at 8.35 A.M. Throughout the day the sun was alternately clear and obscured by clouds. At Davos-Platz it did not rise until 9.44 A.M. At 10 A.M. the mercurial thermometer with blackened bulb *in vacuo* showed 44° C. (111°·2 Fahr.) in the sunshine, and 45° C. (113° Fahr.) at 2.50 P.M. At Greenwich the readings on this day with the blackened bulb *in vacuo* placed on the grass * in the sunshine were:—at 9 A.M., 9°·3 C. (48°·7 Fahr.), at noon and at 3 P.M., 21°·9 C. (71°·5 Fahr.), the maximum during the day being 21°·9 C. (71°·5 Fahr.). The maximum temperature observed in the shade was 10°·9 C. (51°·7 Fahr.), and the minimum on grass in the shade 2°·1 C. (35°·7 Fahr.).

December 22*nd*.—A mercurial thermometer with black glass bulb was laid on the snow at 8 A.M.; twenty minutes later, or fifteen minutes before sunrise, it marked −18°·3 C. (−1° Fahr.). The sky was deep blue, and almost perfectly cloudless during the whole day. Five minutes after sunrise many of the patients at the Seehof Hotel were walking in the open air without any special wraps, and many of them without overcoats. In the brilliant sunshine one felt comfortably warm sitting in front of the hotel in a light morning coat. The following thermometrical observations were made on this day:—

---

* Since the above was written I have ascertained that the readings of this kind of instrument are much higher when it is laid on grass than when it is clamped upon a staff at a height of 5 feet above the ground. Thus, at St. Leonard's-on-Sea on the 7th of April last, this thermometer in sunshine stood at 42°·3 C. at 11.50 A.M., when placed 5 feet from the ground, but when laid on the grass it promptly rose to 56°·5 C. It is therefore evident that the readings of the solar thermometer at Greenwich, given throughout this paper, are much too high for fair comparison with the Davos temperature, the thermometer at Greenwich having been always laid upon the grass. On the 7th of April the sky at St. Leonard's was clear, the air warm with but little wind, and the sun bright; nevertheless the maximum temperature during the day in sunshine was 2°·7 C. lower than that observed with the same instrument at Davos on the 21st of December last.—May 7, 1874.

I. Blackened bulb *in vacuo*. In sunshine.

8.45 A.M.	8.50 A.M.	9.0 A.M.	9.45 A.M.	10.15 A.M.	10.45 A.M.	11.15 A.M.	Noon.	Light cloud, 12.40 P.M.	Clear, 1.45 P.M.
22°·0 C.	26°·0 C.	30°·0 C.	37°·3 C.	39°·3 C.	39°·5 C.	41°·2 C.	42°·4 C.	37°·2 C.	43°·0 C.

This thermometer was clamped to an alpenstock at a height of about five feet from the snow in all the observations recorded in this paper. At Greenwich the readings were, with blackened bulb *in vacuo* :—maximum 12°·8 C. (55° Fahr.); at 9 A.M., 8°·5 C. (47°·3 Fahr.); at noon and at 3 P.M., 12°·8 C. (55° Fahr.). The maximum in the shade was 10°·4 C. (50°·7 Fahr.), and the minimum on grass in the shade −1°·7 C. (28°·9 Fahr.).

II. Plain mercurial thermometer with black glass bulb. In sunshine.

9.45 A.M.	10.15 A.M.	11.15 A.M.	Noon.	1.45 P.M.
−1° C.	0°·6 C.	3°·3 C.	3°·3 C.	7°·2 C.

III. Plain mercurial thermometer with black glass bulb. In shade.

10.15 A.M.	11.15 A.M.	Noon.	1.45 P.M.
−4°·0 C.	−1°·0 C.	−1°·0 C.	−2°·0 C.

IV. Plain mercurial thermometer with black glass bulb, placed in a box lined with padded black cloth and covered with plate-glass $\frac{1}{4}$ inch thick.

9.45 A.M.	10.15 A.M.	Noon.	12.35 P.M.	2 P.M.
75°·0 C.	85°·0 C.	100°·0 C.	102°·8 C.	105°·0 C.

Thus in mid winter the unconcentrated solar rays at Davos are capable of producing, under favourable circumstances, a temperature of 221° Fahr.,—9° Fahr. above the boiling-point of water at the sea-level, or 21° Fahr. above that point at Davos, where I found water to boil at 200° Fahr. when the barometer stood at 627·3 millims.

December 23rd.—The sky was again deep blue and cloudless nearly the whole of the day. The atmospheric pressure was 627·3 millims., and the temperature eight minutes before sunrise, as shown by a black-glass-bulb thermometer laid upon the snow, was again −18°·3 C. (−1° Fahr.). The following thermometric observations were made :—

I. Blackened bulb *in vacuo*. In sunshine.

90 A.M.	9.30 A.M.	11.0 A.M.	11.15 A.M.	11.30 A.M.	12.15 P.M.	2.0 P.M.	Light clouds, 2.23 P.M.
28°·5 C.	35°·5 C.	37°·2 C.	39°·0 C.	39°·0 C.	39°·6 C.	40°·0 C.	34°·0 C.

II. In the shade, the plain mercurial thermometer, with black glass bulb, stood at −9°·4 C. (15·1° Fahr.) at 11.30 A.M. It was freely suspended in the air at a height of about three feet from the snow.

At Greenwich the readings were, with blackened bulb *in vacuo* :—maximum 22°·8 C. (73° Fahr.) ; at 9 A.M., 4°·4 C. (40° Fahr.) ; at noon, 12°·6 C. (54°·6 Fahr.) ; at 3 P.M., 22°·8 C. (73° Fahr.). The maximum in the shade was 8°·3 C. (46°·9 Fahr.), and the minimum on grass in the shade −2°·3 C. (27°·9 Fahr.).

December 24th.—As the Fluela pass, the highest carriage-road in Switzerland, was still open for sledges, I determined to make some observations on the summit, which is 7890 feet above the sea, and consequently about 2538 feet above Davos. Starting from Davos at 8 A.M., I arrived at the summit of the pass, where there is a small hotel and telegraph station, at 10.30 A.M.

The early morning was somewhat cloudy, but, about ten o'clock, the sky became perfectly clear and deep blue, and continued so until the sun set behind the Schwarzhorn, a few minutes past noon. The following temperatures were recorded :—

I. The blackened bulb *in vacuo* marked 41°·7 C. at 11 A.M. in the sunshine, 42°·3 C. at 11.30 A.M., and 42°·3 C. at 12 o'clock.

II. The plain black glass bulb in the shade showed at noon −7°·2 C. when freely suspended about two feet above the snow in a brisk breeze.

The highest temperature in sunshine which I have observed at Davos at noon, with the blackened bulb *in vacuo*, was 42°·5, which scarcely differs from that read on the Fluela pass at the same hour. So far as these limited observations go, therefore, they indicate that the solar rays are not of appreciably higher thermal intensity at a height of 7890 feet than at a height of 5350 feet. I may add that the thermometer in the sunshine was sheltered from the wind on the Fluela pass, and was, in all respects but one, in a more favourable position for attaining a high temperature than at Davos. The one unfavourable condition was its exposure to less solar heat reflected from the snow than at Davos.

At Greenwich the readings were, with blackened bulb *in vacuo* :— maximum 19°·5 C. (67°·1 Fahr.) ; at 9 A.M., 9°·6 C. (49°·3 Fahr.) ; at noon, 18°·6 C. (65°·5 Fahr.) ; and at 3 P.M., 19°·5 C. (67°·1 Fahr.). The maximum in the shade was 10°·5 C. (50°·9 Fahr.), and the minimum on grass in the shade −3°·1 C. (26°·5 Fahr.).

December 25th.—The sky was again deep blue and perfectly cloudless. The air was also apparently clear, except at about 9 A.M., when the village and valley became immersed in a light fog, which consisted of minute snow crystals. On this and most subsequent days isolated crystals could be distinctly seen floating in the air, by placing the eye in shadow and then looking into the sunshine. The abundance or paucity of these suspended and, under ordinary circumstances, invisible snow crystals must exercise a powerful influence upon the intensity of solar radiation. To this cause, for instance, it was probably due that at 1.45 P.M. on this day, although the sky was perfectly clear and the sunshine most intensely brilliant, the blackened bulb *in vacuo* only stood at 35° C. in the sun, whereas at noon, when all the conditions were apparently the same (except, of course, the sun's altitude), the temperature was 5° C. higher. The following readings were taken :—

I. Blackened bulb *in vacuo*. In sunshine.

9.0 A.M., frozen fog.	9.15 A.M., clear.	10.20 A.M., clear.	11.15 A.M., clear.	Noon, clear.	1.45 P.M., clear.
22°·5 C.	32°·5 C.	37°·9 C.	39°·2 C.	40°·0 C.	35°·0 C.

II. The black glass bulb on the snow eight minutes before sunrise marked −12°·8 C. At noon in the shade it stood at −9°·1 C. Height of barometer 630 millims.

At Greenwich the readings were, with blackened bulb *in vacuo* :— maximum 10°·4 C. (50°·8 Fahr.) ; at 9 A.M., 4°·6 C. (40°·3 Fahr.) ; at noon and at 3 P.M., 10°·4 C. (50°·8 Fahr.). The maximum in the shade was 7°·5 C. (45°·5 Fahr.), and the minimum on grass in the shade −2°·7 C. (27°·2 Fahr.).

December 26th.—Not the smallest cloud was visible during the whole of this day. The sky was intensely blue and the air perfectly calm. Atmospheric pressure 630 millims. Fifteen minutes before sunrise the thermometer on the snow marked −16°·7 C. At 1.50 P.M. the same thermometer in the shade stood at −4°·1 C. The following readings in the sunshine were made with the blackened bulb *in vacuo* :—

8.45 A.M.	9.0 A.M.	10.0 A.M.	10.30 A.M.	11.0 A.M.	11.30 A.M.	Noon.	12.30 P.M.	1.0 P.M.	2.30 P.M.	2.50 P.M.
22°·0 C.	31°·8 C.	39°·8 C.	40°·8 C.	42°·5 C.	43°·7 C.	42°·5 C.	42°·7 C.	42°·0 C.	31°·0 C.	33°·1 C.

At Greenwich the readings were, with blackened bulb *in vacuo*:—maximum 8°·8 C. (47°·9 Fahr.); at 9 A.M., 6°·7 C. (44° Fahr.); at noon and at 3 P.M., 8°·8 C. (47°·9 Fahr.). The maximum in the shade was 8°·2 C. (46°·7 Fahr.), and the minimum on grass in the shade 4° C. (39°·2 Fahr.).

December 27th.—A cloudless morning and deep blue sky. Eight minutes before sunrise the thermometer on the snow indicated −17°·2 C. At 10.25 A.M. the black bulb *in vacuo* registered in the sunshine 36°·5 C. and at noon 38°·5 C. The afternoon was cloudy and no observations were made.

At Greenwich the readings were, with blackened bulb *in vacuo*:—maximum 13°·6 C. (56°·4 Fahr.); at 9 A.M., 7°·5 C. (45°·5 Fahr.); at noon 6°·2 C. (43°·1 Fahr.); and at 3 P.M. 13°·6 C. (56°·4 Fahr.). The maximum in the shade was 8°·4 C. (47°·2 Fahr.), and the minimum on grass in the shade −3°·7 C. (25°·3 Fahr.).

December 28th.—At 4.30 A.M. there was a violent storm of wind with snow; afterwards moderate wind with snow until the afternoon. The barometer stood at 615 millims. At 2 P.M. the blackened bulb *in vacuo* registered 28° C. in sunshine.

At Greenwich the readings were, with blackened bulb *in vacuo*:—maximum 0°·7 C. (33°·2 Fahr.); at 9 A.M., −0°·5 C. (31°·1 Fahr.); at noon and at 3 P.M. 0°·7 C. (33°·2 Fahr.). The maximum in the shade was 0°·6 C. (33° Fahr.), and the minimum on grass in the shade was −8°·4 C. (16°·9 Fahr.).

December 29th.—Sky deep blue and quite free from cloud during the whole day. Barometer 620 millims. At 8 A.M. the thermometer on the snow stood at −22°·2 C. A spirit thermometer (not verified), 4 feet from the ground, indicated −22°·1 C. At noon the thermometer in the shade stood at −18°·1 C. The following observations were made with the blackened bulb *in vacuo*:—

9.0 A.M.	10.0 A.M.	11.0 A.M.	11.30 A.M.	Noon.	4 minutes after sunset, 3.30 P.M.
18°·0 C.	30°·0 C.	33°·7 C.	37°·0 C.	33°·7 C.	−12°·0 C.

At Greenwich the readings were, with blackened bulb *in vacuo*:—maximum 28°·4 C. (83°·2 Fahr.); at 9 A.M., −1°·6 C. (29°·2 Fahr.); at noon, 28°·3 C. (82°·9 Fahr.); and at 3 P.M., 28°·4 C. (83°·2 Fahr.). The maximum in the shade was 4°·2 C. (39°·5 Fahr.), and the minimum on grass in the shade was −9°·6 C. (14°·8 Fahr.).

December 30th.—Sky deep blue and perfectly free from cloud during the whole day. Barometer 621·7 millims. At 8 A.M. the thermometer on the snow stood at −26°·4 C. (−15°·5 Fahr.). A self-registering minimum

spirit thermometer (unverified), fixed to a post 4 feet above the snow, recorded −18° Fahr. as the minimum temperature during the night of December 29–30th. At 2 P.M. the thermometer in the shade stood at −12°·8 C. The air was apparently equally clear throughout the whole day. The following readings of the blackened bulb *in vacuo* in sunshine were made:—

9.0 A.M.	9.30 A.M.	10.0 A.M.	11.30 A.M.	12.15 P.M.	1.30 P.M.	2.0 P.M.
25°·5 C.	32°·3 C.	35°·0 C.	37°·5 C.	35°·2 C.	38°·5 C.	33°·7 C.

At Greenwich the readings were, with blackened bulb *in vacuo*:—maximum 22°·9 C. (73°·2 Fahr.); at 9 A.M., 2°·7 C. (36°·9 Fahr.); and at 3 P.M., 22°·9 C. (73°·2 Fahr.). The maximum in the shade was 7°·5 C. (45°·5 Fahr.), and the minimum on grass in the shade was −4°·9 C. (23°·1 Fahr.).

December 31*st*.—Sky deep blue, sun quite free from clouds during the whole day. Very light streaks of cloud appeared in the S.W. just before sunset. Barometer 621·5 millims. At 8 A.M. the thermometer on the snow registered −23°·6 C.; at noon the thermometer in the shade stood at −10°·C. A naked thermometer with smoked black glass bulb freely suspended registered only −2°·8 C. at 9.30 A.M. in sunshine. During the day abundance of snow crystals were frequently observed to be floating about in the air. The blackened bulb *in vacuo* was read in the sunshine as follows:—

9.30 A.M.	10.0 A.M.	11.0 A.M.	Noon.	12.30 P.M.	2.0 P.M.	2.50 P.M.
32°·9 C.	36°·5 C.	38°·7 C.	39°·0 C.	40°·0 C.	35°·0 C.	21°·5 C.

At Greenwich the readings were, with blackened bulb *in vacuo*:—maximum 24°·4 C. (76° Fahr.); at 9 A.M., 8°·1 C. (46°·6 Fahr.); at noon, 21°·3 C. (70°·4 Fahr.); and at 3 P.M., 24°·4 C. (76° Fahr.). The maximum in the shade was 10°·4 C. (50°·7 Fahr.), and the minimum on grass in the shade was 0°·6 C. (33°·1 Fahr.).

January 1*st*, 1874.—A cloudy morning. Sun only slightly visible before 9 A.M.; afterwards brilliant between the clouds. Barometer 625 millims. At 8.15 A.M. the thermometer on the snow marked −13°·9 C., and the unverified self-registering minimum −17°·3 C. At 11.30 A.M. the thermometer in the shade stood at −3°·3 C. The following readings of sunshine temperatures were made with the blackened bulb *in vacuo*:—

9.0 A.M., cloudy.	9.30 A.M., slight cloud over sun.	9.45 A.M., sun clear, rest of sky cloudy.	10.0 A.M., clear.	10.30 A.M., cloudy.	11.30 A.M. cloudy.	12.30 P.M., cloudy.
−1°·0 C.	30°·5 C.	43°·5 C.	44°·0 C.	21°·3 C.	18°·5 C.	11°·5 C., had been 23° C. since 11.30 A.M.

The afternoon and night were cloudy.

At Greenwich the readings were, with blackened bulb *in vacuo* :— maximum 19°·6 C. (67°·3 Fahr.) ; at 9 A.M., 2°·8 C. (37° Fahr.) ; at noon and at 3 P.M., 19°·6 C. (67°·3 Fahr.). The maximum in the shade was 8°·1 C. (46°·6 Fahr.), and the minimum on grass in the shade was −1°·2 C. (29°·9 Fahr.).

January 2nd.—A cloudy morning. Sun not visible until nearly 9 A.M. ; afterwards clear and calm, except at about 10.40 AM., when a few light clouds appeared. Minimum temperature during the night, as measured by an unverified spirit thermometer, −9°·2 C. At 8 A.M. the thermometer on the snow stood at −6°·7 C. ; atmospheric pressure 627·8 millims. At noon the thermometer in the shade stood at −5° C., and at 3 P.M. it registered −4°·6 C. The following observations were made with the blackened bulb *in vacuo* :—

9.0 A.M.	9.15 A.M.	10.0 A.M.	10.30 A.M.	10.40 A.M.	Noon.	12.30 P.M.	1.30 P.M.	3.0 P.M.
29° C.	38° C.	40° C.	41° C.	31°·5 C.	43° C.	40° C.	41° C.	27°·5 C.

At Greenwich the readings were, with blackened bulb *in vacuo* :— maximum 14°·2 C. (57°·5 Fahr.) ; at 9 A.M., 9°·3 C. (48°·8 Fahr.) ; at noon and at 3 P.M., 14°·2 C. (57°·5 Fahr.). The maximum in the shade was 10°·4 C. (50°·7 Fahr.), and the minimum on grass in the shade was 2°·6 C. (36°·6 Fahr.).

January 3rd.—A calm but cloudy morning. At sunrise the thermometer on the snow registered −6°·9 C. The unverified spirit minimum showed the lowest temperature during the night to have been −11° C. Barometer 624 millims. At 11 A.M. the sun was just visible, and in the afternoon the clouds became still thinner. At 12.15 P.M. the thermometer in the shade stood at +0°·8 C. The blackened bulb *in vacuo* stood at 9° C. at 9 A.M. and also at 11 A.M. Between 11 and noon it rose to 29° C. At 12.15 P.M. it marked 15°·5 C., and between that hour and 2 P.M. it reached 28° C., whilst at 2 P.M. it stood at 25° C.

At Greenwich the readings were, with blackened bulb *in vacuo* :— maximum 23°·8 C. (74°·9 Fahr.); at 9 A.M., 7°·2 C. (44°·9 Fahr.); at noon 10°·4 C. (50°·8 Fahr.); and at 3 P.M., 23°·8 C. (74°·9 Fahr.). The maximum in the shade was 9°·2 C. (48°·6 Fahr.), and the minimum on grass in the shade was −·4° C. (31°·3 Fahr.).

During the winter of 1870–71 a series of meteorological observations were made at Davos by Mr. Arthur Wm. Waters, F.G.S., but I am not aware whether the instruments used were verified. The minimum temperatures observed with a Hermann's metallic spiral thermometer were :—

	At Davos.	Corresponding temperature at Greenwich.
November, 1870	−10°·7 C.	− 5°·5 C.
December, 1870	−29°·5 C.	−15°·7 C.
January, 1871	−20°·7 C.	−11°·1 C.
February, 1871	−18°·7 C.	− 5°·0 C.

The maximum sun-temperatures observed with a blackened bulb *in vacuo* were :—

	At Davos.	Corresponding temperature at Greenwich.
November, 1870	46°·3 C.	35°·1 C.
December, 1870	46°·1 C.	26°·0 C.
January, 1871	47°·3 C.	26°·6 C.
February, 1871	52°·2 C.	38°·8 C.

The chief remarkable things about the observations made last winter are, first, the very high sun-temperatures prevailing contemporaneously with very low air- or shade-temperatures, and secondly, the comparative uniformity of the solar heat from sunrise to sunset. Thus on the 29th of December, whilst the temperature of the air was −18°·1 C., the sun-thermometer stood at +37° C., and on the following day, with an air-temperature not exceeding −12°·8 C., the sun-temperature was 38°·5 C. Again, the sun-temperatures observed on the 26th of December illustrate the comparative uniformity of solar radiation during the day, when the sky remains cloudless. Twenty-five minutes after sunrise the solar thermometer indicated 31°·8 C.; at noon it stood at 42°·5 C., and at thirty-five minutes before sunset it recorded 33°·1 C.

Besides the intensity of solar radiation and its comparative uniformity during the day, the rarity and calmness of the air are important factors amongst the causes of the peculiar climate of Davos. With the barometer standing at 615 millims. the weight of air in contact with a given surface of the skin is about one fifth less than it is at the sea-level. The excessive dryness of the air at Davos has probably but little special influence upon the sensation of heat and cold, because the maximum proportion of aqueous vapour present in air near 0° C. is everywhere small, and the specific heats of equal volumes of air and aqueous vapour are not widely

different. On the other hand, the absence of suspended watery particles in the air has, no doubt, very considerable influence in preventing the chilling of the skin. Not only are such liquid particles present when there is visible fog, but they often exist in great numbers when the air possesses its usual transparent appearance. Another very important influence upon the sun-temperature is the reflection of solar rays from the snow. The valley of Davos is about one mile wide, and has precipitous sides and a flat sole. The villages of Davos-Dörfli and Davos-Platz are situated on the north-west slope of the valley, and consequently receive the scattered solar rays reflected from a large area of snow. I have no doubt that the sun-temperature at the opposite side of the valley is markedly lower; but having no second sun-thermometer, I could not ascertain this by the comparison of simultaneous thermometric observations. When staying at Ventnor, in the winter of 1872–73, I noticed that a not inconsiderable proportion of the total solar heat falling upon a house on a cliff, near the shore, was reflected from the sea. M. Dufour has since observed the same phenomenon between Lausanne and Vevay on the Lake of Geneva*, and has actually measured the proportions of direct and reflected heat incident at five different stations on the northern shore of the lake. He found that the proportion of reflected heat was as much as 68 per cent. of the heat directly incident from the sun, when the sun's altitude was between 4° 38′ and 3° 34′. At about 7° altitude the proportion was between 40 and 50 of reflected to 100 of direct heat. Even at about 16° altitude the proportion was between 20 and 30 of reflected to 100 of direct heat; but when the sun was higher than 30°, the reflected heat was hardly appreciable. It will be seen that this action of extensive reflecting surfaces of snow or water must exert a powerful influence upon the maximum temperature of places favourably situated for receiving the reflected rays; and, moreover, where the proportion of heat reflected varies (as it has been proved to do in the case of water, and as it doubtless also does in the case of snow) inversely as the angle formed by the incident rays and the reflecting surface, this action must materially contribute, especially in winter, to the maintenance of an approximately uniform sun-temperature throughout the day. At Davos and similar elevated stations, however, the comparative freedom of the air from suspended liquid and solid particles must obviously contribute, to a still greater extent, to such a result; for as pure and dry air is transcalent and reflects light but slightly, the horizontal sunbeams, passing through such air, would be nearly as powerful as vertical rays.

The peculiar winter climate of Davos appears, therefore, to depend upon the following conditions:—

1. *Elevation above the sea*, which causes greater rarity of the air, and

* Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences, June 30th, 1873.

consequently less abstraction of heat from the body. It also secures greater transcalency in the atmosphere by a position above the chief region of aqueous precipitation, and which is comparatively out of the reach of the dust and fuliginous matters that pollute the lower stratum of the air. On my journey from London to Davos I never saw the sun until I had arrived nearly at my destination; and during the greater portion of the fortnight of brilliant weather recorded above, there was a dull leaden sky at Zürich, about 60 miles distant.

2. *Thick and (during the winter months) permanent snow*, which reflects the solar heat and prevents the communication of warmth to the air, and consequently the production of atmospheric currents. In still, though cold, air the skin is well known to be less chilled than in much less cold air, which impinges with considerable velocity upon the surface of the body. The effect of motion through the air upon the sensation of warmth and cold at Davos is very striking. Sitting perfectly still in the sunshine, the heat in mid winter is sometimes almost unbearable; on rising and walking about briskly, a delicious feeling of coolness is experienced; but on driving in a sledge, the cold soon becomes painful to the unprotected face and hands.

3. *A sheltered position favourable for receiving both the direct and reflected solar rays.*—In this respect Davos-Dörfli, situated opposite to the entrance of the Dischma valley, has the advantage over Davos-Platz, two miles lower down the valley; for, in the latter village, the sun rises on the 21st December $1^h\ 9^m$ later, and sets about ten minutes earlier, than at Dorfli.

All these conditions contribute not only to a high sun-temperature during the winter months, but also to a comparatively uniform radiant heat from sunrise to sunset.

In conclusion I will only point to the general bearing which these observations have upon winter refuges for invalids. While the primary conditions to be secured in such places must ever be fine weather and a sheltered position, the next in importance is, undoubtedly, exposure all day long to reflected, as well as direct, solar radiation. To accomplish this, a southern aspect and a considerable expanse of water, or nearly level snow, are necessary; and it is important that the sanitarium should be considerably, and somewhat abruptly, elevated above the reflecting surface, so that it may receive, throughout the entire day, the uninterrupted reflection of the sun's rays. At the sea-side, for instance, only those houses which command such an uninterrupted view of the sea, ranging from S.E. to S.W., as shows the reflection of the sun throughout the entire day, enjoy the full advantages of the place. At, or near, the sea-level, however, it is impossible, owing to the suspended matters in the lower regions of the atmosphere, to enjoy any thing approaching to a uniform temperature from sunrise to sunset. For this purpose it is necessary to leave the grosser air of the plains behind, and to ascend

some 4000 or 5000 feet into the mountains, when, in these latitudes at least, the reflecting surface must necessarily be snow.

In the above remarks I have confined myself strictly to the physical aspect of the subject; but it is obvious that, in seeking an alpine sanitarium, the patient comes under new conditions of respiration, and breathes air comparatively free from zymotic matter—circumstances which are probably not without profound influence upon his health.

III. Addition to the Paper, "Volcanic Energy: an attempt to develop its true Origin and Cosmical Relations"*. By Robert Mallet, A.M., C.E., F.R.S., M.R.I.A., &c. Received April 3, 1874.

(Abstract.)

Referring to his original paper (Phil. Trans. 1873), the author remarks here that, upon the basis of the heat annually dissipated from our globe being equal to that evolved by the melting of 777 cubic miles of ice at zero to water at the same temperature, and of the experimental data contained in his paper, he had demonstrated, in terms of mean crushed rock, the annual supply of heat derivable from the transformation of the mechanical work of contraction available for volcanic energy, and had also estimated the proportion of that amount of heat necessary to support the annual vulcanicity now active on our globe; but, from the want of necessary data, he had refrained from making any calculation as to what amount in volume of the solid shell of our earth *must* be crushed annually, in order to admit of the shell following down after the more rapidly contracting nucleus. This calculation he now makes upon the basis of certain allowable suppositions, where the want of data requires such to be made, and for assumed thicknesses of solid shell of 100, 200, 400, and 800 miles respectively.

From the curve of total contraction (plate x. Phil. Trans. part i. 1873) obtained by his experiments on the contraction of slags, he has now deduced partial mean coefficients of contraction for a reduction in temperature of 1° Fahr., for intervals generally of about 500° for the entire scale, between a temperature somewhat exceeding that of the blast-furnace and that of the atmosphere, or 53° Fahr. And applying the higher of these coefficients to the data of his former paper, and to the suppositions of the present, he has obtained the absolute contraction in volume of the nuclei appertaining to the respective thicknesses of solid shell above stated. In order that the shell may follow down and remain in contact with the contracted nucleus, either its thickness must be in-

* Read June 20, 1872; Phil. Trans. for 1873, p. 147.